**State of California**
**The Resources Agency**
**Department of Water Resources**

# SP-W3. RECREATIONAL FACILITIES AND OPERATIONS EFFECTS ON WATER QUALITY

# YEAR 1 PROGRESS REPORT

## Oroville Facilities Relicensing
## FERC Project No. 2100

**AUGUST 2004**


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## REPORT SUMMARY

This report describes results of the first year of a two-year monitoring program to assess effects of recreational facilities in and around the Oroville Facilities on water quality within the Project area and the need to modify or mitigate Project operations.

Monitoring programs were designed to target specific recreational facilities and activities with the potential to introduce contaminants into Project waters. The specific monitoring programs included: recreation facilities water quality sampling; swim areas bacteria sampling; fishing tournament/weekend water quality sampling; Bidwell Marina water quality sampling; Lime Saddle Boat Yard boat maintenance activity analyses; and storm event water quality sampling.

The water quality sampling sites were chosen to target the specific type of contaminant from each facility or activity that could potentially affect Project waters. Parameters included bacteria, metals, nutrients, pesticides, petroleum byproducts, and special substances of concern (PBDE, TBT). Water quality data collection was performed monthly during the high-use recreation season (June to September) or during a specific event. Bacteria sampling was also performed monthly except for bi-weekly sampling in the 30-day period around the Fourth of July holiday. Data obtained from the monitoring programs were compared to water quality goals and criteria for protection of beneficial uses.

The current recreational facilities seem to have a minimal effect to water quality. Most of the tested parameters at the monitoring stations were no different from the background levels found in Lake Oroville open-water stations, with the exception of MTBE and bacteria. MTBE, which was rarely found at the open-water stations, exceeded water quality criteria at all of the boating related facilities.

The results of the bacteria sampling at the swim areas indicate that water quality is poor. Bacteria levels are routinely high at most of the developed swim areas and occasionally at the undeveloped swim areas. Bacteria levels sometimes greatly exceed water quality criteria. While levels of bacteria were extremely high during the 30-day period around the Fourth of July holiday, the levels of bacteria remained high for two months after the end of the recreation season. This may indicate that wildlife is a major source of the bacteria.

The results of the water quality sampling during the fishing tournament/weekend sampling show that fishing tournaments and the increased boat traffic during the weekend do impact the water quality of the surface waters. MTBE exceeded water quality criteria in the surface waters around the Spillway boat ramp during a fishing tournament. The heavy weekend use, observed at Bidwell Canyon boat ramp and marina, also impacted water quality through the increased boat traffic.

Results of water quality sampling at Bidwell Marina indicate that there is very little effect from the presence of the facility on water quality of Lake Oroville other than as a high-density boat traffic location. MTBE exceeded water quality criteria in the surface waters around the marina, as did the MTBE levels at all of the other boating related facilities.

Analyses of samples from the Lime Saddle Boat Yard indicate that sand used for paint stripping could potentially contribute some amount of contamination to Project waters. While there were no criteria exceeded, samples did contain a number of metals and petroleum byproducts in significant amounts over the limits of detection.

Storm event sampling performed in November and December 2003 indicates that storm runoff from recreational facilities could affect water quality in Project waters. Arsenic, manganese, and zinc exceeded water quality criteria at very high levels.

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# 1.0 INTRODUCTION

Existing and future operations of the Oroville Project recreational facilities may have effects on the physical, chemical, and biological integrity of water quality. The Environmental Work Group identified issues related to the recreational facilities and operations of the Project. Issues identified included potential for introduction of nutrients, bacterial contamination at swim areas, such as the North Forebay, sewage spills into Lake Oroville, fuel spills as a result of fluctuating lake levels, and contamination from boat maintenance and cleaning products. This study assessed the potential effects on the water quality by the presence of recreational facilities within and adjacent to the Project area.

Numerous recreational and related activities occur within the Project boundary. Various bike, horse, and hiking trails, boat launching and maintenance facilities, camping areas, concessions, waste handling facilities, and swim areas have been developed in association with the Project. The proximity of recreational facilities and their associated activities to the shoreline and banks of Project waters offers potential for shoreline erosion and introduction of nutrients and bacterial contaminants. Recreational activities may also introduce contaminants into Project waters, such as methyl tertiary butyl ether, oil and grease from watercraft operation and maintenance, petroleum hydrocarbons from fuel spills and floating gas tanks, and nutrients and bacteria from floating septic holding systems, restrooms, watercraft gray water tanks, and pump out facilities.

A study plan was developed and approved by the Environmental Work Group to evaluate the effects from recreational facilities and operations on water quality. Task 1 of that study plan was to evaluate the potential for recreation facilities to affect water quality in the Project area and develop appropriate monitoring. The results of that task and proposed monitoring were presented in an interim report to the Environmental Work Group in April of 2003. This report presents the results of the first year of assessment and monitoring performed under the two-year monitoring plan accepted by the Environmental Work Group.

## 1.1 BACKGROUND INFORMATION

The potential for recreational facilities to affect water quality within the Project area was a concern to the Environmental Work Group. The study presented in the Task 1 interim report identified the potential sources of contamination to Project waters from recreational facilities, and proposed specific monitoring to assess this potential contamination.

### 1.1.1 Statutory/Regulatory Requirements

Demonstration of compliance with water quality standards and other appropriate requirements is necessary in the application for water quality certification. Some

physical, chemical, and biological data had been collected prior to initiation of the FERC relicensing studies from the North, Middle, and South forks of the Feather River near their confluences with Lake Oroville, from the reservoir itself, and downstream from Oroville Dam in the Feather River, Thermalito Power Canal, and Thermalito Afterbay. However, these older data are not, nor were expected to be, sufficient to determine compliance with all Basin Plan standards and appropriate goals and criteria protective of the designated beneficial uses. Therefore, additional water quality data were deemed necessary by the Environmental Workgroup to determine effects of the Project to water quality. The additional data obtained by this study plan will be used for evaluation of Project effects to water quality and are necessary for the application for water quality certification.

Information obtained from the study was used to determine effects from recreational facilities, operations, and activities on the physical and chemical components of water quality, and the need for mitigation for impacts to water quality. This analysis is required for water quality certification by the State Water Resources Control Board (SWRCB). The water quality certification is needed for license renewal with the Federal Energy Regulatory Commission (FERC).

### 1.1.2 Study Area

The study area is generally within the FERC Project boundary, but also includes adjacent lands and waterways for effects to Project waters, and downstream for Project effects in the Feather River. Specific water bodies included in the study area are Lake Oroville, the Feather River downstream from Oroville Dam within the Project boundary, the Diversion Pool, the Thermalito Forebay and Afterbay, and the Oroville Wildlife Area ponds.

## 1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational

facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

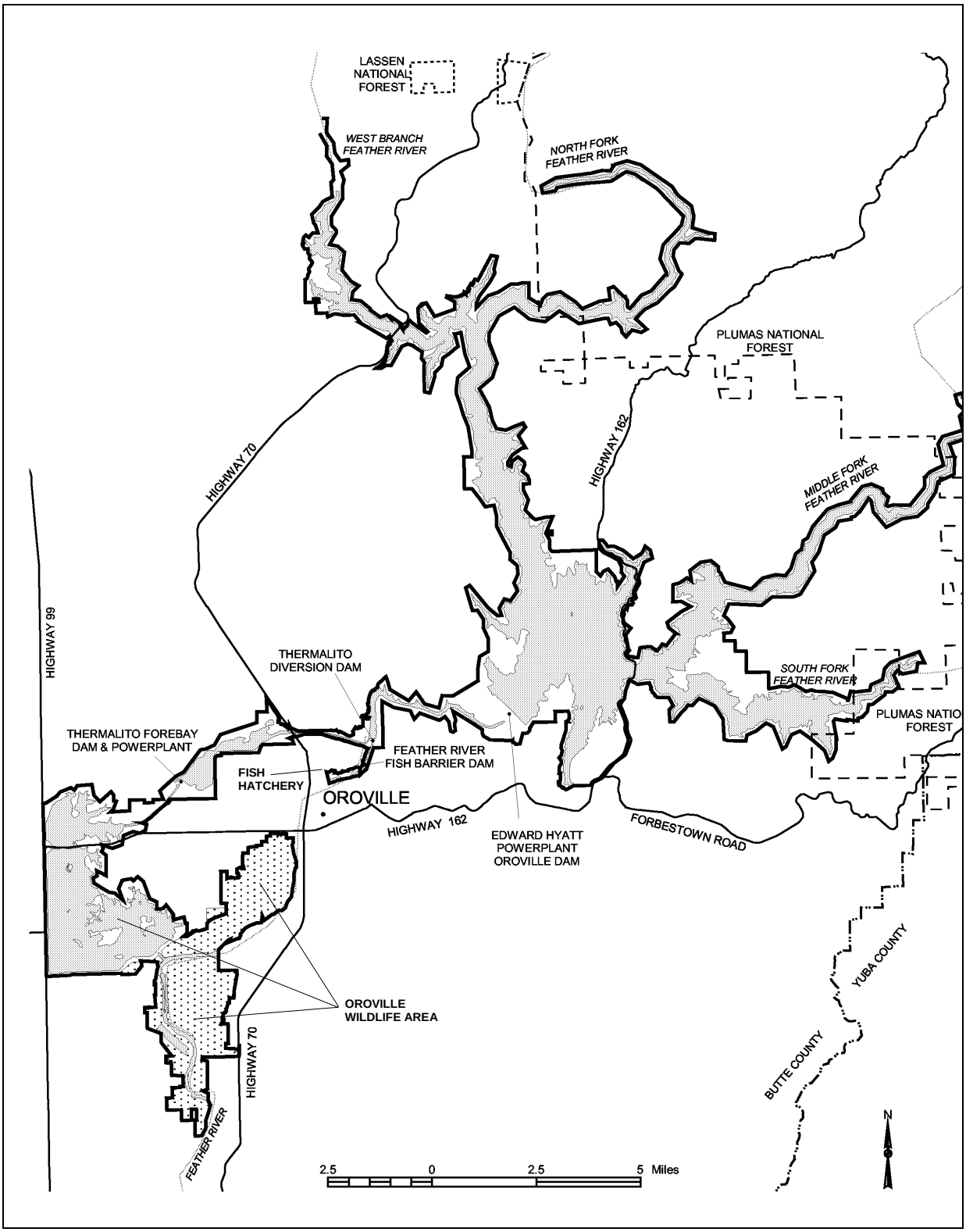


**Figure 1.2-1. Oroville Facilities FERC Project Boundary.**

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 and 5,610 cubic feet per second (cfs), respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam, creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cfs of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about developed facilities and the natural environment. Major recreation facilities are at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service

marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

## 1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for Project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

### 1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish

& Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

#### *1.3.1.1 Instream Flow Requirements*

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

#### *1.3.1.2 Temperature Requirements*

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52 ºF for September, 51 ºF for October and November, 55 ºF for December through March, 51 ºF for April through May 15, 55 ºF for last half of May, 56 ºF for June 1-15, 60 ºF for June 16 through August 15, and 58 ºF for August 16-31. A temperature range of plus or minus 4 ºF is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook

and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65 ºF on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65 ºF from approximately April through mid May, and 59 ºF during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

#### *1.3.1.3 Water Diversions*

Monthly irrigation diversions of up to 190,000 af (July 2002) are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

#### *1.3.1.4 Water Quality*

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

### 1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of

storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

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## 2.0 NEED FOR STUDY

Demonstration of compliance with water quality standards and other appropriate requirements are necessary in the application for water quality certification. Previously existing data were determined to be insufficient for evaluating effects of the Project to water quality. Therefore, additional water quality data were deemed necessary by the Environmental Workgroup to determine Project effects to water quality.

Information obtained from the study will be used to determine effects from recreational facilities, operations, and activities on the physical, chemical, and biological components of water quality, and the need for mitigation for impacts to water quality. This analysis is required for water quality certification by the State Water Resources Control Board. The water quality certification is needed for license renewal with the Federal Energy Regulatory Commission.

## 3.0 STUDY OBJECTIVE(S)

The objective of this study is to determine the effects of Project-related recreational facilities and activities on the water quality of those areas adjacent to and under the influence of Project waters. This study will provide information to be used to identify potential protection, mitigation, and enhancement measures.

# 4.0 METHODOLOGY

This study evaluated the effects of the disparate recreational facilities and activities to natural water quality through several water quality sampling programs. The water quality sampling sites were chosen to reflect the specific type of contaminant from each facility or activity that could potentially affect Project waters.

This study focused on evaluating the potential for recreation facilities, operations, and activities to affect water quality, and monitoring was performed to determine the extent of potential contamination. Data obtained from the study were compared to water quality goals and criteria for protection of beneficial uses. Some future recreational facilities and operations are known, but others will not be known until near the end of the study. Information from recreation study plans was obtained, as necessary, to evaluate potential contamination and their sources from recreation facilities, operations, and activities.

The current Lake Oroville State Recreation Area map was reviewed for completeness and updated to insure that all recreational facilities and activities have been identified. The potential types of contamination associated with each type of recreational facility and activity were identified. Field surveys were conducted to determine potential sources of contamination from recreation facilities and activities. Operators of recreation facilities were contacted, recreation facilities visited, and recreational activities reviewed to determine potential for contamination to Project waters. The interviews and field visits were conducted to identify potential sources of contamination, potential contaminants, source pathways, and operations and management that may contribute to contamination.

Specific monitoring was developed following determination of the potential for each type of recreational facility and activity to contaminate Project waters. The contribution of contaminants from wildlife was also investigated where appropriate, such as waterfowl contribution to bacterial levels at swim areas. The monitoring programs were designed to target specific recreational facilities and activities with potential to introduce contaminants into Project waters.

Monitoring for effects to water quality from recreational facilities and activities was dependent upon the type of recreational facility or activity and the period of impact. Parameters monitored include bacteria, metals, nutrients, pesticides, petroleum byproducts, and special substances of concern (PBDE, TBT). Weekly and event-based (e.g., holiday weekends, recreation or fishing tournaments, spills) water quality data collection was performed during the recreation season or event.

The evaluation of the effects to water quality by the recreational facilities was separated into specific monitoring programs, and will be presented separately, as shown below:

- WQ Sampling Program 1 – Recreation facilities WQ sampling
- WQ Sampling Program 2 – Swim areas bacteria sampling
- WQ Sampling Program 3 – Spillway Boat Ramp Fishing Tournament Sampling
- WQ Sampling Program 4 – Bidwell Marina Special Sampling
- WQ Sampling Program 5 – Lime Saddle Boat Yard Sand Analyses
- WQ Sampling Program 6 – Storm Event Sampling 2003

## 4.1 WQ SAMPLING PROGRAM 1 – RECREATION FACILITIES WQ SAMPLING

The Task 1A study determined the types of recreational facilities, operations, and activities that could adversely affect the physical, chemical, or biological integrity of Project waters. Each of the facilities within or adjacent to the Project boundary were inventoried and assessed for potential impacts. This information identified types of facilities and potential contaminants, as well as potential sources of contamination, source pathways, operations and management that may contribute to contamination, and effectiveness of facility or operations in preventing contamination. There were twenty-four types of recreational facilities and activities identified that may have an impact on water quality and the types of contamination that could occur from that facility or activity (Table 4.1-1).

Twenty-seven water quality sampling sites were selected to assess the potential for contamination from each facility or activity that could be of concern (Table 4.1-2). Some facilities required more than one sampling site, such as the marinas, while in other types of facilities, such as the boat ramps/launches, only a representative number of facilities were chosen for sampling (Table 4.1-2).

**Table 4.1-1. Types of recreational facilities and potential contamination.**

| Recreational Facility Type | Number of Facilities | Potential Contamination |
|---|---|---|
| ATV/ORV | 1 park: The Claypit, 317 acres | No impact expected |
| Bike/Hiking/ Horse trail | 4 trails/approximately 70 miles in length | Sediment (erosion); bacteria & organics from horse manure; petroleum byproducts from parking |
| Boat/car top access | 11 points around Lake Oroville (5), Thermalito Afterbay (1), OWA (1), and Feather River (4) | Sediment (erosion, road runoff); petroleum byproducts |
| Boat, power | Lake wide on Lake Oroville, Thermalito Afterbay, and the south Forebay | Petroleum byproducts; erosion (boat waves) |
| Boat, house | Moorages at Bidwell Canyon (~200) and Lime Saddle Marinas (~150) | Bacteria & organics from sewage; petroleum byproducts |
| Boating/no power | Lake wide on Lake Oroville, Thermalito Afterbay, and the south Forebay | No impact expected |

| Recreational Facility Type | Number of Facilities | Potential Contamination |
|---|---|---|
| Boat ramp/launch | 9 paved boat ramps/launches on Lake Oroville (5), Thermalito Forebay (2) and Afterbay (2) | Sediment (erosion, road runoff); petroleum byproducts |
| Boat-in camping | 3 campgrounds/Bloomer, Craig Saddle, and Goat Ranch | Bacteria & organics from sewage; petroleum byproducts |
| Boat, maintenance facilities | 3 boat yards/Bidwell Canyon, Lime Saddle, and North Forebay Marinas | Petroleum byproducts; paint flakes & dust; cleaning products; sand |
| Campfire center; Campground; Camping/group | 4 campgrounds/ Bidwell Canyon, Lime Saddle, Loafer Creek, Oroville Wildlife Area | Sediment (erosion, road runoff); bacteria & organics from sewage; pesticides |
| Camping, floating | 4 campsites on Lake Oroville: Canyon Creek, Potter Ravine, Stringtown, Union Creek | Bacteria & organics from sewage and human contact; petroleum byproducts; garbage |
| Concessions | 2/ Bidwell Canyon and Lime Saddle Marinas | Petroleum byproducts; metals; garbage |
| Dump station | 2/ Lime Saddle Campground, Loafer Creek RA | Bacteria & organics from sewage |
| Equestrian camp | 1/ Loafer Creek RA | Bacteria & organics from sewage |
| Fish cleaning station | 5 stations/ Bidwell Canyon, Lime Saddle, Monument Hill, Spillway, Thermalito Forebay South | Organic materials |
| Hunting | Oroville Wildlife Area, Thermalito Afterbay | No impact expected |
| Marina | 2/ Bidwell Canyon, Lime Saddle Marinas | Petroleum byproducts; bacteria & organics from sewage; heavy metals from boat antifouling paint, pesticides, wood preservatives, & biocides; fuel additives; sediment (erosion, road runoff, & sandblasting); garbage |
| Nature study | Oroville Wildlife Area | Sediment (erosion, road runoff) |
| Picnicking | 12/ Lake Oroville (6), Thermalito Forebay (2) and Afterbay (2), Feather River (2) | Erosion; garbage |
| Restrooms | associated with most developed facilities | Bacteria & organics from sewage |
| Restrooms, floating | 10 around Lake Oroville | Bacteria & organics from sewage |
| Swimming | 8/ identified in Task 2 below | Bacteria & organics from sewage and human contact, and garbage |
| Trailhead/with parking | 1/ Fall River Trail | Sediment (erosion, road runoff); petroleum byproducts |
| Special Events | Lake wide on Lake Oroville and Thermalito Afterbay | Petroleum byproducts; organics; erosion (boat waves) |

**Table 4.1-2. Recreational WQ stations – Types and locations.**

| Station | Facility Type | Latitude/ **Longitude** |
|---|---|---|
| Bidwell Canyon Marina | Marina | N39° 32' 1.699" W121° 27' 17.156" |
| Bidwell Canyon Boat Ramp | Boat ramp/launch | N39° 32' 20.017" W121° 27' 23.205" |
| Bidwell Canyon Houseboat Moorage 1 | Houseboat mooring | N39° 32' 18.753" W121° 26' 55.408" |
| Bidwell Canyon Houseboat Moorage 2 | Houseboat mooring | N39° 31' 5.771" W121° 27' 16.536" |
| Bloomer Primitive Boat-in Campground | Boat-in campground | N39° 36' 35.430" W121° 29' 31.711" |
| Bloomer Floating Restroom | Floating restroom | N39° 37' 36.008" W121° 29' 7.778" |
| Canyon Creek Floating Campground | Floating campground | N39° 34' 53.045" W121° 25' 49.163" |
| Craig Saddle Boat-in Campground | Boat-in campground | N39° 32' 50.874" W121° 24' 23.349" |
| Goat Ranch Boat-in Campground | Boat-in campground | N39° 39' 24.558" W121° 29' 54.576" |
| Kelly Ridge Floating Restroom | Floating restroom | N39° 32' 54.787" W121° 27' 44.485" |
| Lime Saddle Marina | Marina | N39° 40' 35.569" W121° 33' 26.706" |
| Lime Saddle Boat Ramp | Boat ramp/launch | N39° 40' 33.610" W121° 33' 29.362" |
| Lime Saddle Houseboat Moorage 1 | Houseboat mooring | N39° 40' 27.775" W121° 33' 9.234" |
| Lime Saddle Houseboat Moorage 2 | Houseboat mooring | N39° 40' 40.894" W121° 33' 36.048" |
| Potter Ravine Floating Campground | Floating campground | N39° 33' 59.753" W121° 28' 49.883" |
| Stringtown Floating Campground | Floating campground | N39° 31' 57.687" W121° 22' 7.429" |
| Union Creek Floating Campground | Floating campground | N39° 34' 47.639" W121° 23' 46.146" |
| Lake Oroville at Oroville Dam | Open water | N39° 32' 29.315" W121° 28' 50.469" |
| Lake Oroville at Deadman Ravine | Open water | N39° 30' 46.461" W121° 27' 27.896" |
| Lake Oroville Main | Open water | N39° 33' 51.140" W121° 27' 17.023" |
| Lake Oroville North Fork | Open water | N39° 35' 57.809" W121° 28' 49.270" |
| Lake Oroville South Fork | Open water | N39° 32' 10.825" W121° 21' 2.699" |

| Station | Facility Type | Latitude/ **Longitude** |
|---|---|---|
| Lake Oroville Middle Fork | Open water | N39° 34' 30.689" W121° 23' 47.082" |
| Thermalito Afterbay North | Open water | N39° 30' 11.501" W121° 40' 59.356" |
| Thermalito Afterbay South | Open water | N39° 29' 23.695" W121° 41' 1.869" |
| Thermalito Forebay North | Open water | N39° 31' 9.134" W121° 37' 8.410" |
| Thermalito Forebay South | Open water | N39° 31' 36.925" W121° 36' 27.039" |

In the North Fork of Lake Oroville, there are eight water quality sampling stations (Figure 4.1-1). Four of these stations are in and around the Lime Saddle Recreational Area on the West Branch of the North Fork of Lake Oroville. These stations include the Lime Saddle Marina, Lime Saddle Boat Ramp, Lime Saddle Houseboat Moorage – West Branch station (Lime Saddle HB1), and Lime Saddle Houseboat Moorage – Lime Saddle Inlet station (Lime Saddle HB2). The remaining four water quality sampling stations are on the Lake Oroville North Fork Arm (also known as The Slot). Two boat-in campgrounds, Goat Ranch and Bloomer, were sampled, as well as the Bloomer Island floating restroom. The SP-W1 station Lake Oroville North Fork (Lake Oroville NF) was also sampled.

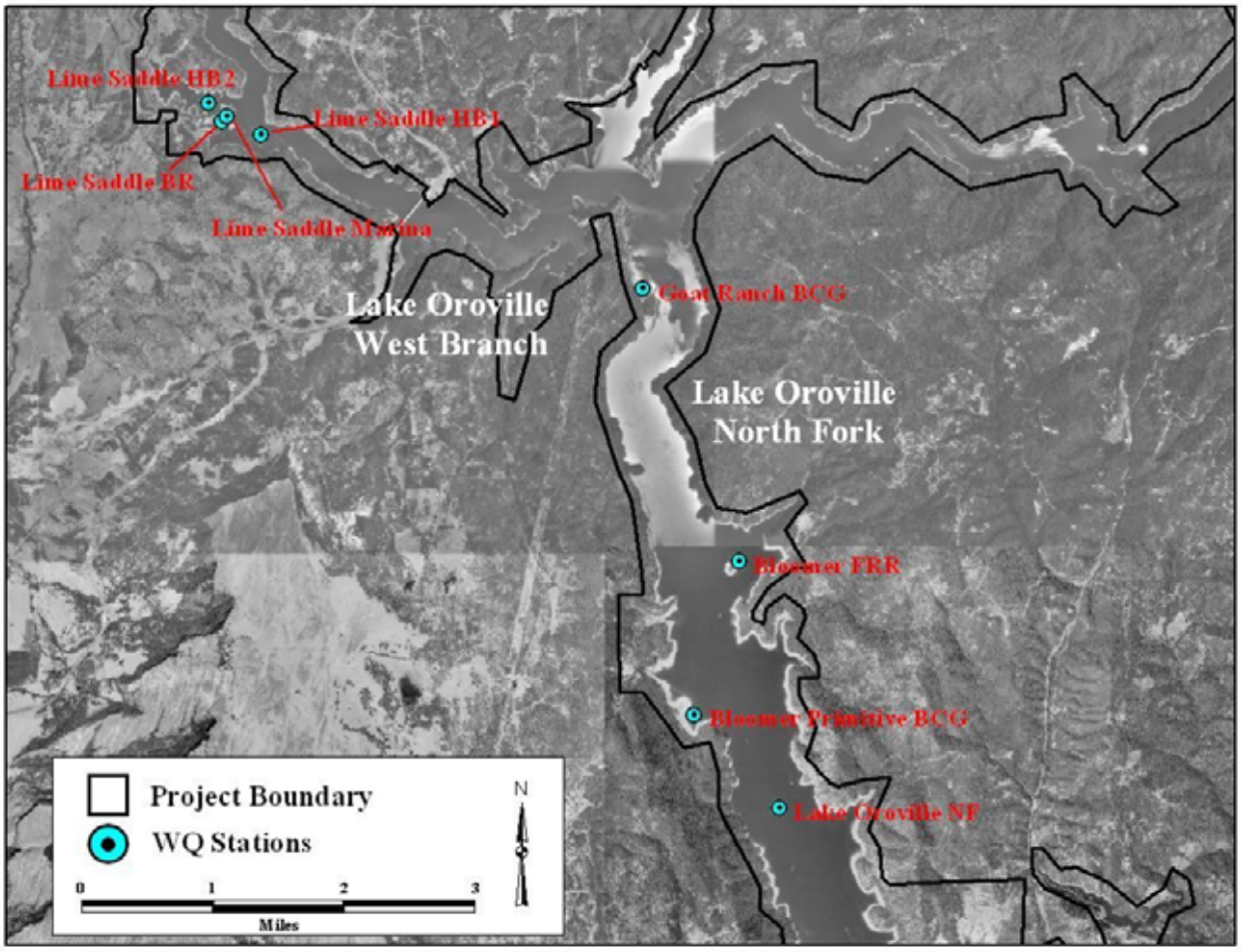
In the main part of Lake Oroville, fourteen stations were sampled (Figure 4.1-2). Four SP-W1 Lake Oroville stations were sampled, including Lake Oroville at Oroville Dam, Lake Oroville Main Body, Lake Oroville Middle Fork, and Lake Oroville South Fork. In the Bidwell Canyon Arm of Lake Oroville, five stations were sampled in and around the Bidwell Canyon Recreational Area, including the Bidwell Canyon Boat Ramp, Bidwell Canyon Marina, two Bidwell Canyon Houseboat Moorages, and Lake Oroville at Deadman's Ravine. Four floating campgrounds were sampled, including Canyon Creek on Lake Oroville Main Body, Potter Ravine at Potter Ravine Inlet, Stringtown on Lake Oroville South Fork, and Union Creek on Lake Oroville Middle Fork. Only one boat-in campground at Craig Saddle on Lake Oroville South Fork was available for sampling.

Four SP-W1 stations were sampled on the Thermalito Afterbay and Forebay, with two stations in the Forebay and two in the Afterbay (Figure 4.1-3).

Parameters sampled were by the potential of the facility or activity to contribute a particular type of contamination (Table 4.1-3). For example, bacteria, metals, nutrients, and petroleum byproducts were selected at Bidwell Canyon Marina due to the presence of restrooms over the water, food store concession, high density of boat and human traffic, fuel pumps, fuel storage tanks, and fuel lines. On the other hand, only bacteria

and nutrients were sampled at the nearby Bidwell Canyon houseboat moorage 2 due to the concern of the houseboat septic holding tanks.

**Figure 4.1-1. Recreational WQ sampling stations – Lake Oroville NF.**

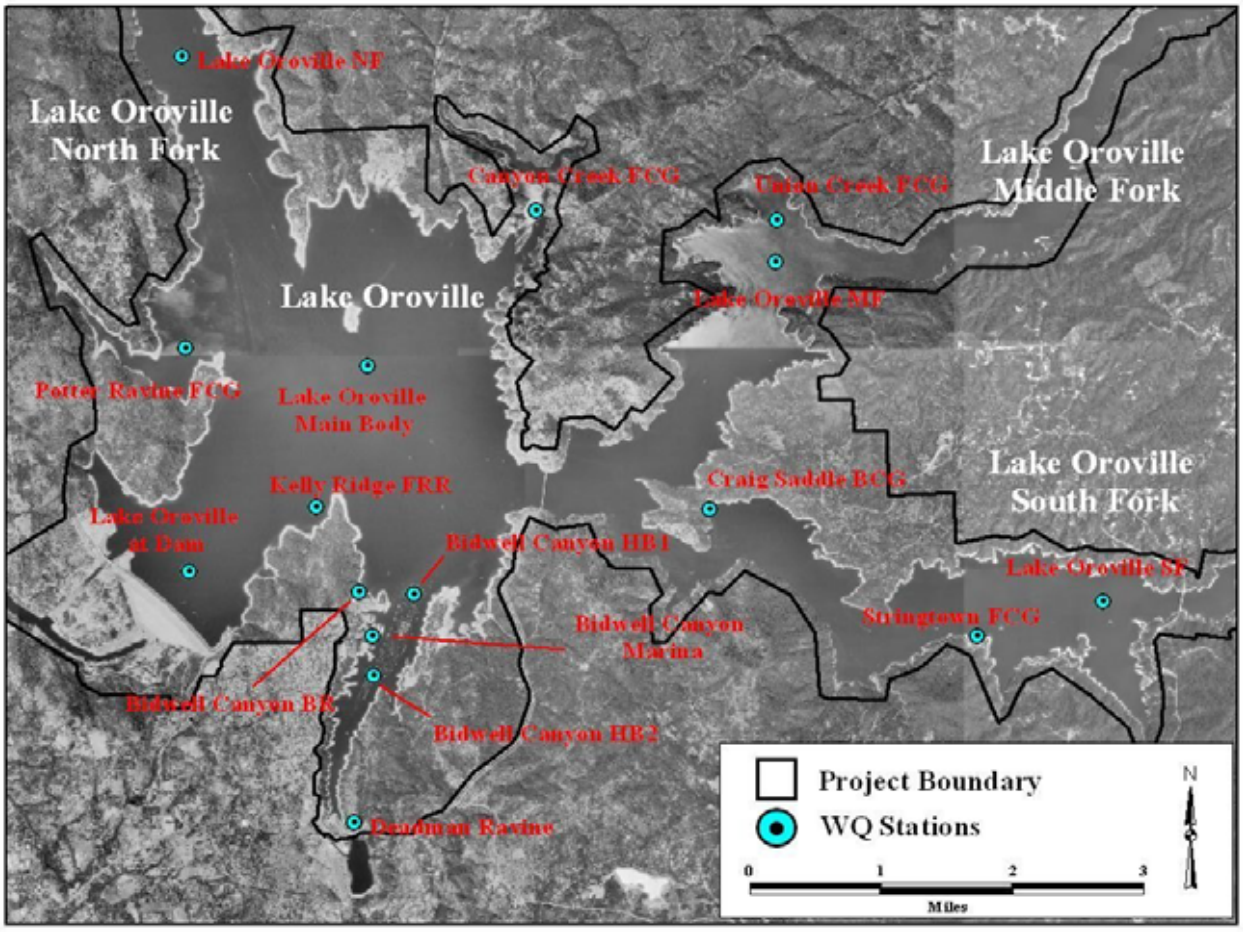



Some facilities, such as the cartop boat access points or the nearly 82 miles of multi-use recreation trails, did not require water quality sampling since the major concern at these sites is erosion or damage to adjacent waters from facility maintenance. Therefore, these types of facilities only required periodic visual inspection for erosion or major changes to the facility (Table 4.1-4).

Monthly sampling began in June 2003 and ended in September 2003 (the high recreational period of the year). Water temperature and conductivity were measured with an Orion Thermo model 130A meter. An Orbeco-Heilige colorimeter kit was used to measure pH, while dissolved oxygen was determined using the modified Winkler titration method (APHA 1998). Nutrient analyses included dissolved and total ammonia, dissolved nitrite-nitrate, dissolved orthophosphate, and total phosphorus. Other

analyses included total metals (Appendix Table 8.1-4) and dissolved metals (Appendix Table 8.1-5), total and dissolved mercury, aromatic hydrocarbons (AH), and polynuclear aromatic hydrocarbons (PAH; Appendix Table 8.1-7).

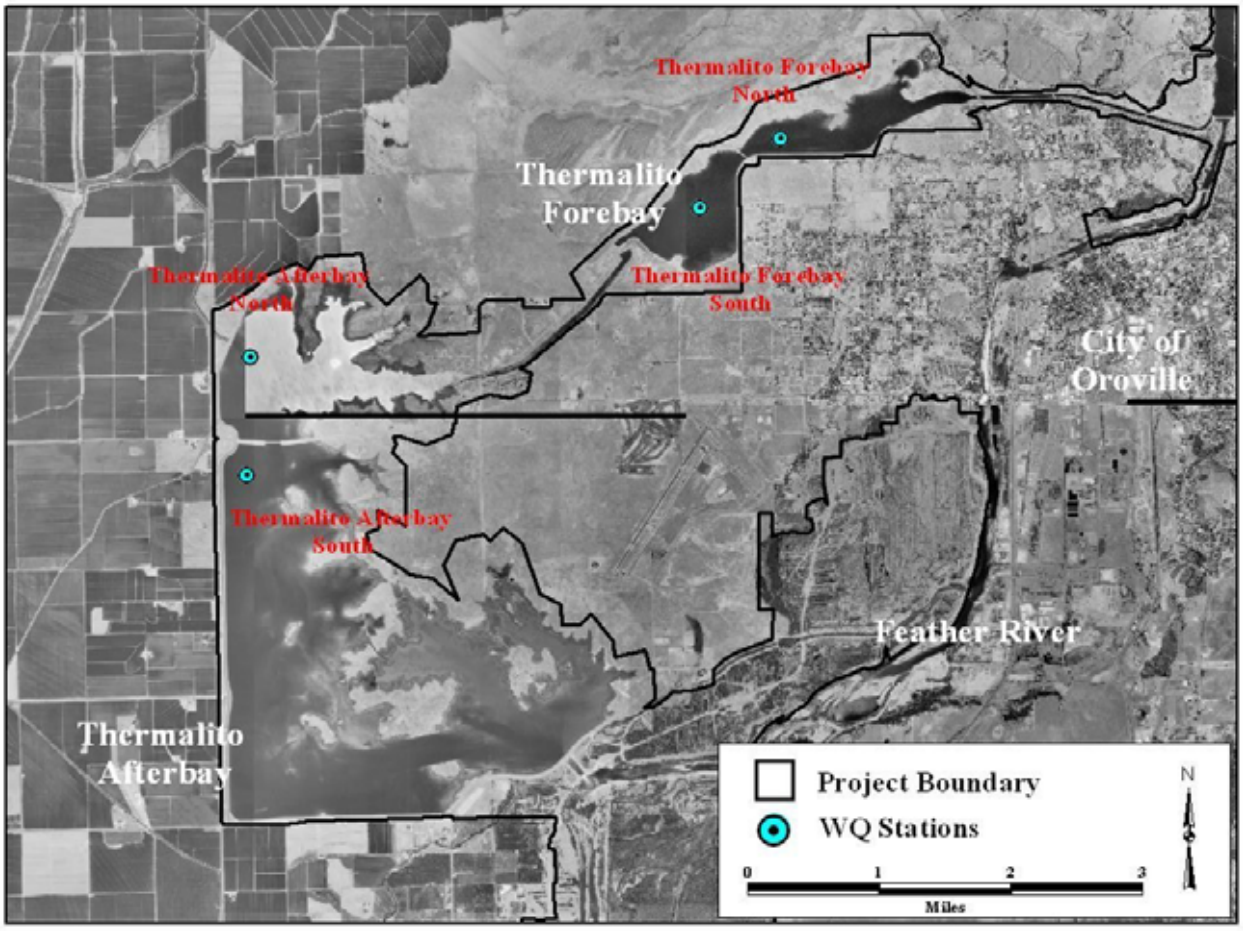
**Figure 4.1-2. Recreational WQ sampling stations – Lake Oroville MF and SF.**




Water samples for the analyses of nutrients were collected in one acid-washed pint polyethylene bottle for total phosphorus and total ammonia and in one acid-washed pint polyethylene bottle for dissolved nutrients. The content of the pint bottle was filtered into an acid-washed pint polyethylene bottle for the analyses of dissolved ammonia and dissolved nitrite-nitrates. For the bacterial sampling, two samples were taken from each site for the analyses of fecal and total coliform, fecal streptococcus, and enterococcus, and were collected monthly for the duration of the recreation season (June through September). Fecal streptococci are normally restricted to the gastrointestinal tract of warm-blooded animals. The enterococcus group of the fecal streptococci is an indicator for determining the extent of fecal contamination of recreational surface waters and is considered the most efficient bacterial indicator of water quality (APHA 1998).

Surface water samples were taken in acid-cleaned one-liter amber glass bottles for the polynuclear aromatic hydrocarbons analyses. Samples for the oil and grease analyses were taken in one-liter amber glass bottles containing hydrochloric acid preservative. Samples for the analysis of aromatic hydrocarbons were taken in 40-mL amber borosilicate-glass vials (two per station).

**Figure 4.1-3. Recreational WQ sampling stations – Thermalito Forebay/Afterbay.**




In the Lake Oroville North Fork/West Branch area, four sites were visited monthly for visual inspection (Figure 4.1-4). Three of the sites are the small boat/cartop boat access ramps located at Dark Canyon, Nelson Bar, and Vinton Gulch. These ramps are paved, being remnants of the old roads that were inundated by the filling of Lake Oroville. The ramps are not regularly improved or maintained, and were checked primarily for erosion and boat or vehicle damage. The Nelson Bar ramp does have a restroom and an extensive parking area. The fourth site is the Lime Saddle Recreational Vehicle Sanitary Dump Station adjacent to the Lime Saddle Marina, which was checked for possible spills.

In the Lake Oroville Main Body/South Fork area, six sites were visited monthly for visual inspection (Figure 4.1-5). Four sites are the small boat/cartop boat access ramps, with two on the Lake Oroville South Fork (Enterprise and Stringtown) and two on Lake Oroville Main Body (Foreman Creek and Spillway). The ramps at Foreman Creek and Stringtown are remnants of old roads that were inundated by filling of the lake. These ramps are not regularly improved or maintained, and were checked primarily for erosion

**Table 4.1-3. Recreational water quality stations - Parameters sampled.**

| Station | Parameters sampled |
|---|---|
| Bidwell Canyon Marina | Bacteria, Metals, Nutrients, Petroleum byproducts |
| Bidwell Canyon Boat Ramp | Metals, Nutrients, Petroleum byproducts |
| Bidwell Canyon Houseboat Moorage 1 | Bacteria, Nutrients, Petroleum byproducts |
| Bidwell Canyon Houseboat Moorage 2 | Bacteria, Nutrients |
| Bloomer Primitive Boat-in Campground | Bacteria, Nutrients, Petroleum byproducts |
| Bloomer Floating Restroom | Bacteria, Nutrients |
| Canyon Creek Floating Campground | Bacteria, Nutrients, Petroleum byproducts |
| Craig Saddle Floating Campground | Bacteria, Nutrients |
| Deadman Ravine @ mouth | Petroleum byproducts |
| Goat Ranch Boat-in Campground | Bacteria, Nutrients, Petroleum byproducts |
| Kelly Ridge Floating Restroom | Bacteria, Nutrients |
| Lime Saddle Marina | Bacteria, Metals, Nutrients, Petroleum byproducts |
| Lime Saddle Boat Ramp | Bacteria, Metals, Nutrients, Petroleum byproducts |
| Lime Saddle Houseboat Moorage 1 | Bacteria, Nutrients, Petroleum byproducts |
| Lime Saddle Houseboat Moorage 2 | Bacteria, Nutrients, Petroleum byproducts |
| Union Creek Floating Campground | Bacteria, Nutrients, Petroleum byproducts |
| Potter Ravine Floating Campground | Bacteria, Nutrients, Petroleum byproducts |
| Stringtown Floating Campground | Bacteria, Nutrients |
| Thermalito Afterbay North | Petroleum byproducts |
| Thermalito Afterbay South | Petroleum byproducts |
| Thermalito Forebay North | Petroleum byproducts |
| Thermalito Forebay South | Petroleum byproducts |
| Lake Oroville at Dam | Petroleum byproducts |
| Lake Oroville Main | Petroleum byproducts |
| Lake Oroville NF | Petroleum byproducts |
| Lake Oroville SF | Petroleum byproducts |
| Lake Oroville MF | Petroleum byproducts |

**Table 4.1-4. Recreational water quality visual inspection only stations – Type and frequency of inspections.**

| Station | Facility Type | Frequency of Inspections |
|---|---|---|
| Bidwell Canyon | Multi-use trail | Prior to start of and after end of rainy season |
| Bidwell Canyon | RV dump station | Monthly from spring to fall |
| Dark Canyon | Cartop boat access | Monthly from spring to fall |
| Enterprise | Boat ramp/launch | Monthly from spring to fall |

| Station | Facility Type | Frequency of Inspections |
|---|---|---|
| Foreman Creek | Cartop boat access | Monthly from spring to fall |
| Lime Saddle | RV dump station | Monthly from spring to fall |
| Loafer Creek | Multi-use trail | Prior to start of and after end of rainy season |
| Loafer Creek | RV dump station | Monthly from spring to fall |
| Mile Long Pond | Cartop boat access | Monthly from spring to fall |
| Monument Hill | Boat ramp/launch | Monthly from spring to fall |
| Nelson Bar | Cartop boat access | Monthly from spring to fall |
| North Forebay | Boat ramp/launch | Monthly from spring to fall |
| North Forebay | Boat ramp/launch | Monthly from spring to fall |
| Oroville (Brad Freeman) | Multi-use trail | Prior to start of and after end of rainy season |
| Oroville (Dan Beebe) | Multi-use trail | Prior to start of and after end of rainy season |
| Oroville Wildlife Area | Primitive campground | Monthly from spring to fall |
| Oroville Wildlife Area | Cartop boat access | Monthly from spring to fall |
| Oroville Wildlife Area | Cartop boat access | Monthly from spring to fall |
| South Afterbay | Cartop boat access | Monthly from spring to fall |
| South Forebay | Boat ramp/launch | Monthly from spring to fall |
| Spillway | Boat ramp/launch | Monthly from spring to fall |
| Stringtown | Cartop boat access | Monthly from spring to fall |
| Thermalito Afterbay Outlet | Cartop boat access | Monthly from spring to fall |
| Vinton Gulch | Cartop boat access | Monthly from spring to fall |

**Figure 4.1-4. Visual inspection sampling stations – Lake Oroville North Fork.**

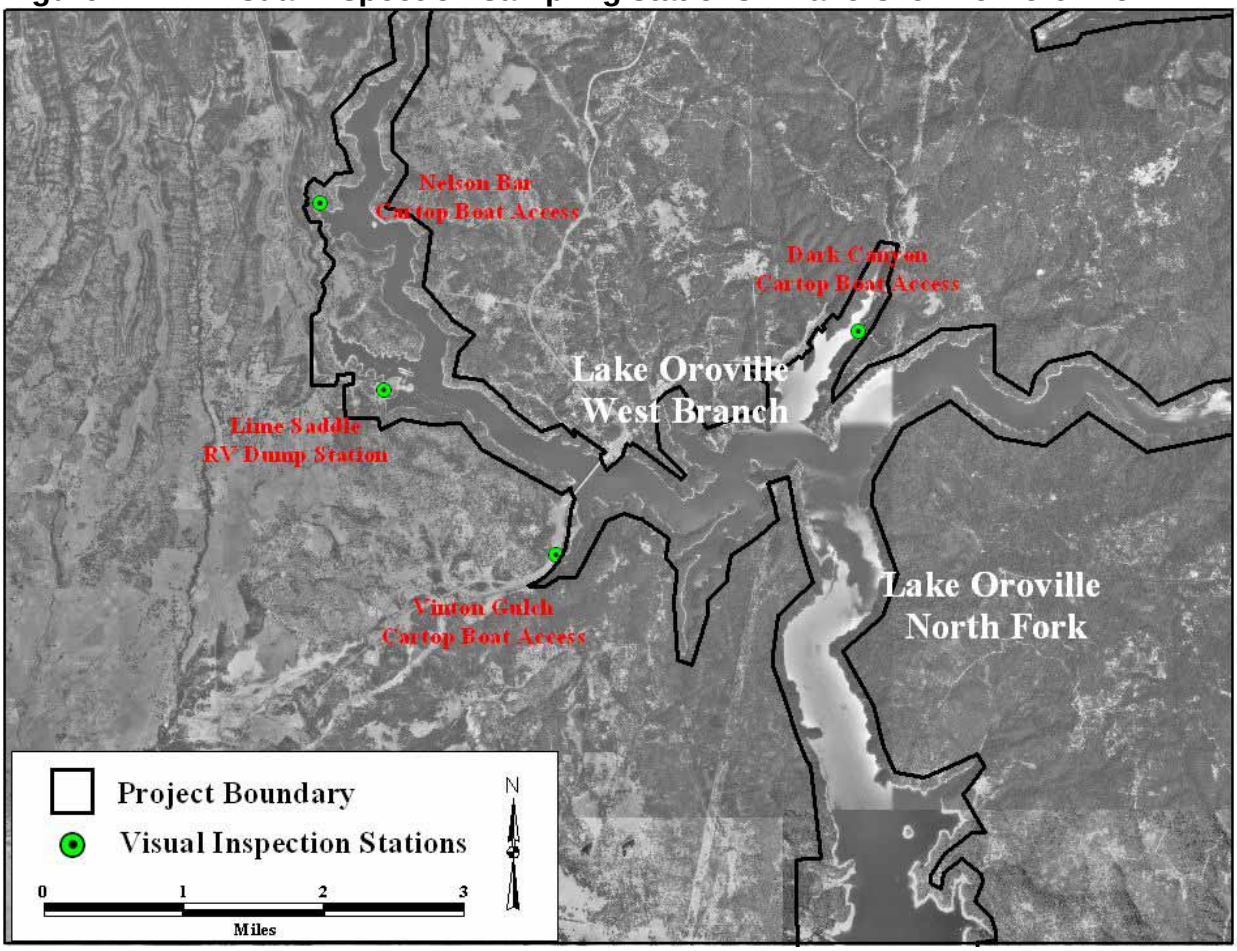
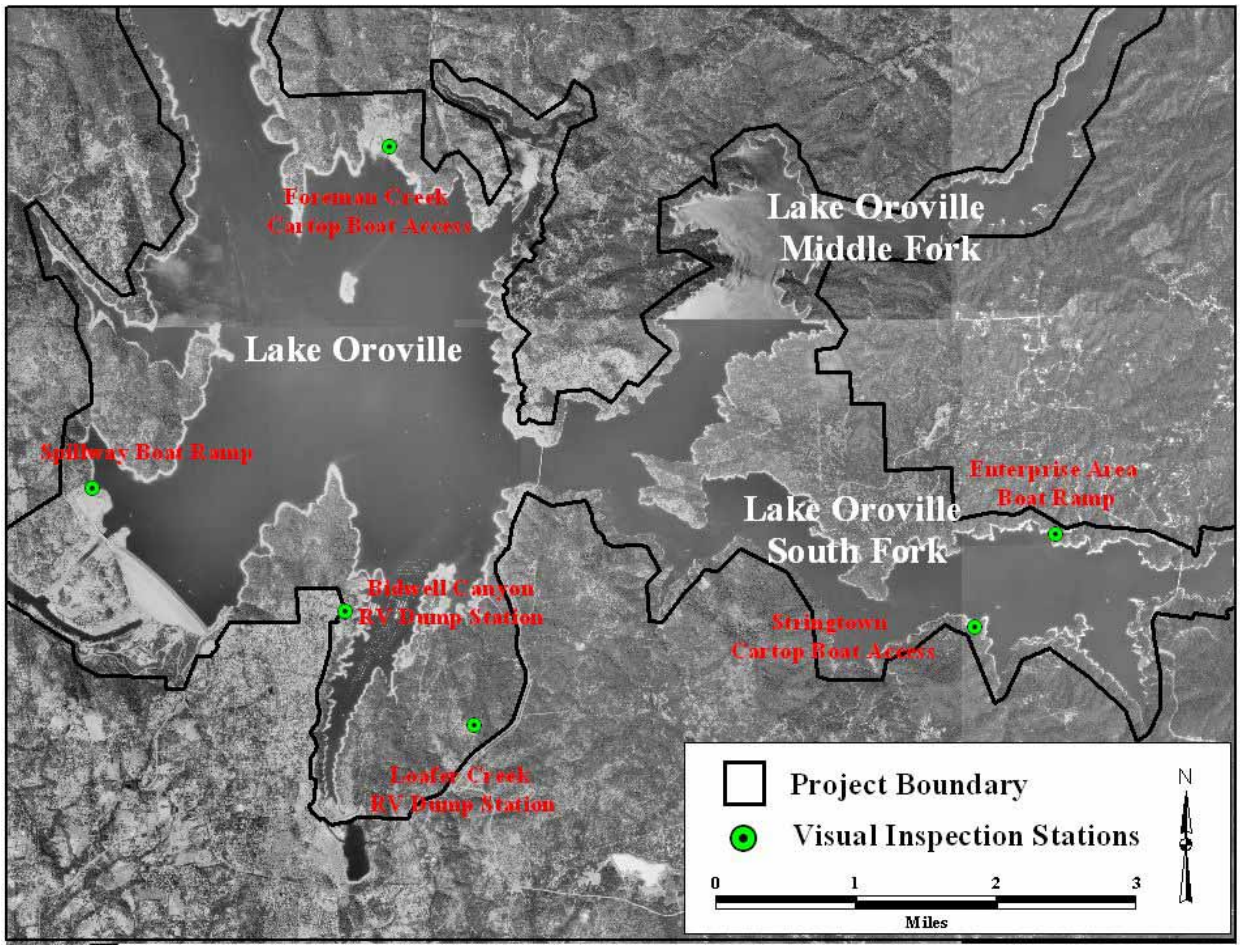


**Figure 4.1-5. Visual inspection stations – Lake Oroville Main, Middle Fork, and South Fork.**




and boat or vehicle damage. The ramps at Enterprise and Spillway were constructed for recreational use. The Spillway ramp has extensive recreational facilities, including a ranger station/booth, restrooms, fish cleaning station, and clearly marked trailheads. The recreational vehicle sanitary dump stations at Loafer Creek Recreational Area and the Bidwell Canyon Recreational Area were checked for possible spills.

In the Thermalito Forebay/Afterbay system, five sites were visited monthly for visual inspection (Figure 4.1-6). On the Forebay, two boat ramps are associated with recreational areas (North Forebay RA and South Forebay RA), and are maintained and operated by CDPR. These ramps have well developed recreation facilities, docks, parking areas, restrooms, picnic areas, and swim areas. The North Forebay ramp is used only for non-motorized water craft, such as sailboats. On the Afterbay, there are two paved boat ramps associated with recreational areas (North Afterbay RA and Monument Hill RA on the South Afterbay). The North Afterbay ramp has minimal facilities, but includes a two-chambered restroom, very limited parking, and a two-lane ramp. The Monument Hill ramp has a six-chambered restroom, extensive parking, a